6. FERMENTED MILKS

6.1 Definitions

Fermented milks have been produced by traditional methods for many centuries, and there are several hundred such products recorded around the world. They are produced as a result of microbial 'souring' of milk, usually cows' milk, but also the milk of other species, including sheep, goat, horse and buffalo. Most are very similar, both in terms of their characteristics, and in the technology used to produce them. Many fermented milk products are distinguished only by their region of origin, and very few have become commercially important. Interest in these products, particularly yoghurt, has grown rapidly since the development of flavoured and fruit yoghurts in Europe in the late 1950s, and more recently as a result of the growing demand for, and marketing of, fermented milks as health-promoting foods.

Fermented milks can be conveniently classified on the basis of the type of fermentation they undergo, as lactic, yeast-lactic (e.g. Kefir, Koumiss, acidophilus-yeast milk) and mould-lactic (e.g. Villi). Lactic fermentation products can be further classified, depending on the characteristics of the lactic microflora, as mesophilic (e.g. Filmjolk, Nordic ropy milk, Maziwa lala, Ymer), thermophilic (e.g. Yoghurt, Labneh, Shirkhand, Skyr, Bulgarian buttermilk) and probiotic or therapeutic (e.g. 'Bio'-fermented milks, acidophilus milk, AB-yoghurt, Yakult, Danone, Cultura-AB). Examples of products of each type are given below.

6.2 Lactic Fermentations

6.2.1 Mesophilic

The genera of microorganisms that fall into this category include *Lactococcus*, *Leuconostoc* and *Pediococcus*. The optimal growth temperature is between 25 - 30 °C.

6.2.1.1 Traditional or natural buttermilk

Traditional or natural buttermilk is made from the liquid produced during butter production using a starter culture mixture of *Lactococcus* spp. (*Lactococcus lactis*

subsp. *lactis*, and *Lactococcus lactis* subsp. *cremoris*, which are the main producers of lactic acid, and *Lactococcus lactis* biovar *diacetylactis*, the diacetyl flavour-producing organism) and *Leuconostoc mesenteroides* subsp. *cremoris* (also responsible for flavour production).

6.2.1.2 Cultured buttermilk

Cultured buttermilk is also produced mostly using a mixed culture of *L. lactis* subsp. *lactis*, *L. lactis* subsp. *cremoris* and the flavour-producing organisms *L. lactis* biovar *diacetylactis* and *L. mesenteroides* subsp. *cremoris*. It is traditionally made from skimmed milk. Ymer is similar to cultured buttermilk, but differs in the sequence of the manufacturing stages.

6.2.1.3 Nordic sour milks

Nordic sour milks such as Filmjolk and Nordic ropy milk are made using slime-producing *Bacterium lacticus longi*, a synonym of *Lactococcus* spp. (the name *Lactococcus lactis* biovar *longi* has been proposed). The slimy or ropy consistency of the products is also attributed to Butterwort leaves, which are rubbed on the interior of the pails.

6.2.1.4 Cultured cream

Cultured cream or sour cream is made using the same starter cultures as cultured buttermilk, but has a much higher fat content (10 - 40%).

6.2.1.5 Miscellaneous products

Miscellaneous products include a range of traditional products that depend on spontaneous fermentation by naturally present lactic acid bacteria (LAB) in milk. Maziwa lala (commercially called Mala) is made using the same starter culture mixture as buttermilk, but is then sweetened. Susa, made from camel's milk is fermented using hetero-fermentative mesophilic starter cultures. Lben is similar to buttermilk but its production involves spontaneous fermentation. The microflora of this product mainly consists of *L. lactis* biovar *diacetylactis*, *Leuconostoc lactis*, *L. mesenteroides* subsp. *cremoris* and *Leuconostoc mesenteroides* subsp. *dextranicum*; lactobacilli, yeast, mould and coliforms are also present.

6.2.2 Thermophilic

This category encompasses those starter cultures whose growth optimum is between 37 and 45 °C. The genera of microorganisms that fall into this category include *Streptococcus* and *Lactobacillus*.

6.2.2.1 Yoghurt

Yoghurt is a term used to describe a wide range of related products, which may be classified according to legal standards (full-, medium- or low-fat), gel type (set or stirred) and whether or not they are flavoured (natural, fruit, or flavoured) or if they are subjected to a further process (heating, freezing, drying or concentrating). The usual starter culture employed to produce yoghurt is a mixture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*.

6.2.2.2 Acid buttermilk

Acid buttermilk, also known as Bulgarian buttermilk is made using *L. delbrueckii* subsp. *bulgaricus* as the starter culture. *Str. thermophilus* or a cream culture may also be included in the starter culture.

6.2.3 Probiotic or therapeutic

LAB such as enterococci, lactococci, propionibacteria, *Leuconostoc*, and pediococci are used as probiotics, but the principal organisms are of the bacterial genera *Lactobacillus* and *Bifidobacterium*.

6.2.3.1 Yakult

Yakult is a term for a group of therapeutic products originating from Japan. The starter culture used is *Lactobacillus casei* subsp. *casei* (*L. casei* Shirota), an organism naturally present in the normal intestinal microflora of humans. The organism is a probiotic strain that is thought to have a beneficial effect on the host, by improving the intestinal microbial balance. The positive health benefits of probiotics are reported to be of particular value in the treatment of diseases that result in a disturbance of the intestinal microflora.

6.2.3.2 Acidophilus milk

Acidophilus milk is a traditional therapeutic milk product popular in eastern Europe, but now attracting more attention elsewhere for its perceived beneficial properties. It may be made from skimmed or whole milk, and the starter organism is *Lactobacillus acidophilus.*

6.2.3.3 'Bio' yoghurts

'Bio' yoghurts are made by very much the same process as traditional yoghurt, and are very similar products, but usually use a mixed starter culture consisting of probiotic strains. *Bifidobacterium* spp. are often used, especially *Bifidobacterium*

bifidum, and *Bifidobacterium longum*, together with lactobacilli, such as *L. casei* and *L. acidophilus*. These organisms are all found in the normal intestinal microflora and are considered to have a beneficial effect on human health.

6.3 Yeast - Lactic Fermentations

Mesophilic LAB, thermophilic LAB and yeast are the main fermentation genera.

6.3.1 Kefir

Kefir is a rather foamy and effervescent fermented milk that contains about 1% lactic acid and 0.5 - 1.0% alcohol, and is popular in eastern Europe and Mongolia. The starter culture consists of small, white 'kefir grains', about 2 - 10 mm in diameter. These grains contain a complex and quite variable microbial community, but little is known about how they develop. The grains usually contain LAB such as *Lactobacillus* spp. (*L. delbreuckii* subsp. *bulgaricus*) plus *Lactococcus* spp. (*L. lactis* subsp. *lactis*), *Leuconostoc* spp., and *Str. thermophilus*, acetic acid bacteria (*Acetobacter aceti* and *Acetobacter rasens*), contaminants such as mould (*Geotrichium* spp.), and a number of yeast species such as *Saccharomyces and Kluyveromyces*, but the principal yeast species present is *Candida kefir* (synonym: *Candida kefyr*; telemorph: *Kluyveromyces marxianus*).

6.3.2 Koumiss

Koumiss is traditionally made in central Asia from mares' milk, but is now often made from skimmed, or whole cows' milk with added sugar. Starter cultures contain LAB such as lactobacilli (*L. delbrueckii* subsp. *bulgaricus* and *L. acidophilus*), strains of lactose-fermenting yeasts (*K. marxianus*, *Saccharomyces* spp., *Torula koumiss*), non-lactose-fermenting and non-carbohydrate-fermenting yeasts. The finished product contains lactic acid, alcohol and carbon dioxide, producing a slightly effervescent drink.

6.3.3 Miscellaneous Products

Miscellaneous products such as acidophilus-yeast milk fall under the yeast-lactic group of fermented products, but little is known about the technology of these beverages.

6.4 Mould - Lactic Fermentations

Mesophilic LAB and mould are the genera responsible for fermentation.

6.4.1 Villi

Villi is a fermented milk product from Finland, which is made from whole milk, using a starter culture of *L. lactis* subsp. lactis biovar *diacetylactis*, *L. mesenteroides* subsp. *cremoris*, and the mould *Geotrichum candidum*. The mould grows on the layer of fat that forms on the top of the product and produces a felt of mycelium.

6.5 Initial Microflora

The initial microflora of fermented milk products is determined largely by the microflora of the whole and skimmed milks from which they are made.

6.6 Processing and its Effects on the Microflora

Although there is a very wide range of fermented milk products, the manufacturing technology used is generally very similar. The principal differences are in the starter cultures used, the composition and treatment of the milk, and the fermentation conditions. Therefore, for the purposes of this chapter, yoghurt manufacture is used as a representative example of fermented milk processes, since yoghurt is the most commercially important of these products. An outline of the process is depicted in Figure 6.1.

6.6.1 Initial processing

Several different varieties of yoghurt are produced, but the three main types are: set; stirred; and drinking yoghurt. Yoghurt is most commonly made from cows' milk, but may also be produced from the milk of sheep, goats, and, occasionally, other animal species.

The composition of yoghurt varies slightly, and in some countries is regulated by legislation. Both whole milk and reduced-fat milks are used to produce yoghurt, but reduced-fat products have the largest market share in most countries. A fat content of approximately 1.5% is typical for a low-fat yoghurt, and the milk is usually standardised to control the final fat content. The protein composition and quality of the milk are important, since they may have a significant effect on texture. Only milk of good microbiological quality should be used, in order to avoid problems of proteolysis associated with bacterial activity, and the production of bacterial proteases by psychrotrophs. These enzymes may significantly alter the physical properties of the yoghurt, and cause defects.

The milk-solids-not-fat (MSNF) content of the milk is usually increased to give a higher viscosity in the finished product. This may be done by fortification with non-fat dried milk or other dairy powders, or by concentration methods, such as evaporation under vacuum, or by membrane filtration (ultra filtration or reverse osmosis). For most yoghurt, an MSNF level of about 15% is typical, but for

drinking yoghurt, levels of less than 11% are preferred. The milk is usually then filtered, to remove undissolved particles, de-aerated to provide conditions that favour rapid starter growth, and homogenised to improve texture and help prevent syneresis. Stabilisers may also be added to stirred yoghurts to improve viscosity and further reduce the likelihood of syneresis. Pre-gelatinised starch or plant gums are the most commonly used stabilisers.

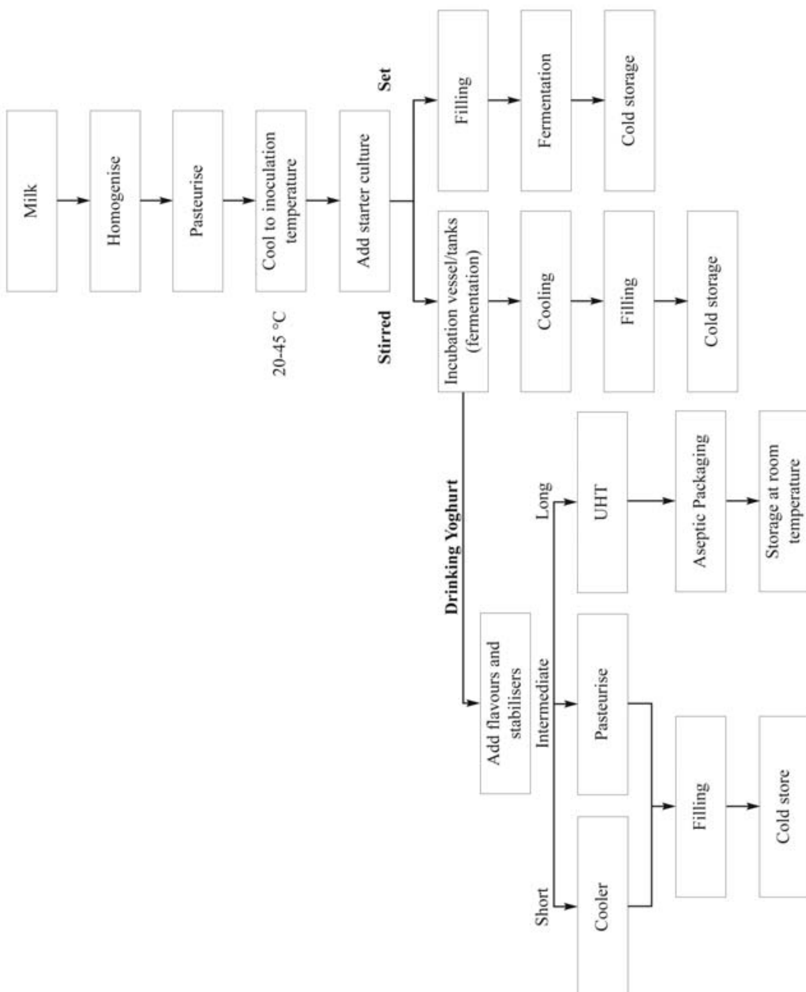

Fig.6.1. Production of stirred and set fermented milk

6.6.2 Heat treatment

A heat treatment is generally applied to milk for yoghurt manufacture. A process of 80 - 85 °C for 30 minutes is typical for batch processes, but, for continuous processes, a heat treatment of 90 - 95 °C for 5 - 10 minutes is more usual. In some cases, a full ultra high temperature (UHT) process (133 °C for 1 second) may be applied. This relatively severe heat treatment has a number of effects. Vegetative bacterial cells, which may include pathogens such as *Salmonella*, are killed, leaving only heat-resistant bacterial spores. Non-pathogenic organisms that might interfere with the growth of the starter culture are therefore reduced to very low levels. The heat treatment also has a significant effect on the final viscosity of the yoghurt, and improves texture by causing denaturation of the whey proteins (albumins and globulins) and the three-dimensional aggregation of casein molecules. The oxygen concentration of the milk is also further reduced, improving conditions for starter culture growth, since the starter organisms are generally microaerophilic. Finally, starter culture activity can either be stimulated or inhibited due to the breakdown products of heat-damaged milk proteins.

6.6.3 Fermentation

After heat treatment, the milk is cooled to 30 or 45 °C and is then inoculated with the starter culture (using long or short incubation periods, respectively). Most commercial yoghurt production now uses a mixed inoculum containing defined strains of *Str. thermophilus* and *L. delbrueckii* subsp. *bulgaricus*. During fermentation, the two starter organisms grow synergistically. Initially, *Str. thermophilus* grows rapidly and produces lactic acid. As the acidity rises, so *L. delbreuckii* subsp. *bulgaricus* becomes more active and produces more acid along with aroma compounds. It has been found that the growth of *Str. thermophilus* stimulates the growth of the *Lactobacillus*, probably by the production of a growth factor, thought to be formic acid, which stimulates proteolytic activity. *Lactobacillus* growth is further stimulated by the production of low levels of carbon dioxide (CO_2) from urea (30 - 50 mg CO_2/kg of milk within the first hour of incubation). The lactobacilli, in turn, stimulate the growth of *Str. thermophilus* by releasing peptides and, to lesser extent, amino acids as by-products of proteolysis.

The specific strains used are chosen for their effect on product flavour and texture, and strains may be used in rotation to prevent occasional problems with bacteriophage infection. Good hygienic practices after pasteurisation are required to prevent build-up of bacteriophage pools in stagnant whey. It is important that the inoculum contains a balanced population of the two organisms, usually a 1:1 ratio. Both liquid and freeze-dried cultures are used. Most commercial manufacturers use an inoculum of about 2 - 3% v/v. Incubation of the inoculated milk at 40 - 45 °C produces a rapid fermentation, which is normally complete within 3 - 4 hours. During this time, lactic acid is produced, giving an eventual

acidity of 0.9 - 0.95% and a pH of approximately 4.6 - 5.0. The starter organisms may also produce aroma compounds, such as acetaldehyde, acetone, acetoin and diacetyl, and exopolysaccharides, which improve texture and viscosity, although if too much extracellular material is produced, a 'ropy' texture fault may result. Set yoghurt is fermented in the final container, but stirred yoghurt is fermented in bulk, and stirred slowly, for only a few minutes, during the process.

6.6.4 Cooling and packing

When fermentation is complete, the yoghurt is initially cooled to about 15 - 20 °C, to minimise further acid production. At this point, sweeteners, flavours and/or fruit purées may be added. These additions must be of good microbiological quality, since, for most yoghurts, no further processing is applied (for set yoghurts, additional ingredients must be added before fermentation). The product is then dispensed into the final containers (stirred yoghurts) and further cooled to < 5 °C. A shelf life of about 3 weeks at this temperature is typical, although acid continues to be produced during this time and may affect flavour. Some yoghurt is heat treated after fermentation to destroy starter organisms, and this increases shelf life to several months. Greek-style, concentrated yoghurts are produced by further separation of the yoghurt after fermentation to increase the fat and solids content. Yoghurt may also be frozen, or dried for use as an ingredient.

6.7 Probiotic products

The production of fermented milks with probiotic organisms is very similar to the basic process for yoghurt, and uses the same key stages. However, the characteristics of the organisms used require that certain modifications be made. Since probiotic bacteria are intended to colonise the gastrointestinal tract of consumers, it is important that the number of viable cells in the product be as high as possible. Direct vat inoculation of probiotic starters is common, using cultures in nutrient-supplemented milk. Bulk starter media may also be used, especially for *Bifidobacterium* spp., which can be difficult to grow. Inoculation rates also tend to be higher for probiotic starters. Rates of 10 - 20% v/v can be used. *Bifidobacteria* are usually used in combination with other LAB as they may produce quantities of acetic acid, which can adversely affect flavour, and to overcome slow acid production.

L. acidophilus is a slow-growing organism and therefore requires a long incubation time to produce sufficient acid. This means that *L. acidophilus* fermentations are likely to be disrupted by spore-forming bacteria in the early stages if these organisms are present in significant numbers. For this reason, the milk is usually given a severe heat process such as 95 °C for one hour, or a UHT treatment, to reduce spore levels.

A further challenge is ensuring the survival of sufficient numbers of the probiotic organisms in the product throughout its shelf life for the product to be

classified as having probiotic properties. Survival is influenced by various factors, including acidity, pH, temperature, and oxygen concentration. Therefore, careful control of these factors during processing and storage is important, as is the initial probiotic strain selection. Recent studies suggest that it is possible to maintain high numbers of viable cells throughout shelf life (1, 2).

6.8 Spoilage

6.8.1 Bacteria

Bacterial spoilage of fermented milks is unlikely. The combination of severe heat treatment, the presence of active starter organisms, low pH and chilled storage prevents the growth of bacterial contaminants. However, if acid production is slow, sporeforming organisms and post-process contaminants may be able to grow. If products are stored at too high a temperature, continued acid production and proteolysis by starter organisms may impair flavour and cause bitterness. If bacteriophage contamination occurs post heating, they may inactivate the starter completely or cause slow acidification. Occasionally, rapid growth of non-starter LAB, present as post-heat treatment contaminants, may also lead to over-acidification and undesirable flavours. It is therefore important to manufacture fermented milks in hygienic conditions to minimise recontamination.

Spoilage of fermented milks, in general, is likely to be caused by yeasts, or by moulds, and most documented cases of spoilage refer to yoghurts.

6.8.2 Yeasts

Acid-tolerant, psychrotrophic, fermentative yeasts may be able to grow in yoghurt, and cause blowing as a result of the production of CO_2. Yoghurts that contain sucrose through the addition of fruit purées, flavours, or chocolate, are particularly vulnerable to this kind of spoilage, since many yeasts are able to ferment sucrose. Species of *Candida*, *Saccharomyces*, *Pichia*, *Rhodotorula*, *Kluyveromyces*, and *Torulopsis* have been isolated from blown packs of yoghurt (3). Fruit purées, cereals, honey, nuts and spices are the most likely source of yeast contamination. Purées used in yoghurt should not contain any detectable yeasts at a level of 1 g, since even low numbers of cells may reduce shelf life. Other sources of contamination are airborne dust particles, contaminated packaging material, poor hygiene on processing lines and other ingredients.

Few yeasts are able to ferment lactose, and therefore natural yoghurt without additions is much less prone to yeast spoilage. The exceptions are *Kluyveromyces marxianus* var. *lactis* and *Kluyveromyces marxianus* var *marxianus*, which will ferment lactose, and are the most common cause of natural yoghurt spoilage. This organism may colonise equipment and surfaces in the yoghurt manufacturing plant, and effective cleaning and hygiene procedures are needed to prevent

contamination (4). This species may also grow at high temperatures, and, if present as a contaminant in a starter culture, could disrupt fermentation.

6.8.3 Moulds

Growth of acid-tolerant moulds in yoghurt is restricted by lack of oxygen, and agitation of the product during transport tends to suppress growth at the surface. However, growth of species of *Mucor*, *Aspergillus*, *Rhizopus*, *Alternaria* and *Penicillium* can occur at the product/air interface during retail storage, leading to the production of mycelial mats or buttons, and visible spoilage. Mould spores may contaminate yoghurt via airborne dust particles, packaging and added ingredients, as well as through poor hygiene (5).

6.9 Pathogens: Growth and Survival

Fermented milks have a good safety record in terms of foodborne disease, and there are very few recorded incidents of food poisoning associated with these products. Milk used in fermentations is generally subjected to a severe heat treatment sufficient to destroy vegetative pathogens. Furthermore, it is generally considered that pathogens are not able to grow in fermented milks, and that their survival is likely to be limited by the low pH, high acid concentrations and presence of inhibitory compounds such as bacteriocins. For example, *Campylobacter* spp. are rapidly killed in the presence of lactic acid.

Experiments to determine the survival of foodborne pathogens in yoghurt and other fermented milks tend to produce quite variable results. Survival times can be influenced by pH, acidity and the characteristics of the starter culture used. Salmonellae are usually considered to be inactivated at levels of lactic acid of > 1% (6), but it is possible that pathogens may adapt to acid conditions over time, and the effect of this adaptation on survival should be considered. There is also a trend towards the development of milder-flavoured products with significantly lower levels of acid. Pathogen survival in these products may be significantly enhanced. Indeed, the length of time over which viable *Salmonella typhimurium* cells could be recovered from inoculated fermented milk was found to increase at lower levels of acid production (7). The demand for fermented milk has lead to the manufacture of these products in unapproved premises; as was highlighted in March 2007 by a Food Alert issued by the Food Standards Agency. Therefore, it is not advisable to rely on low pH and acid production to ensure product safety; effective hygiene procedures to prevent pathogen contamination during processing are also necessary.

6.9.1 Listeria monocytogenes

It is generally considered that *L. monocytogenes* is unlikely to be able to grow in fermented milks, but survival in the finished product is possible.

The behaviour of *L. monocytogenes* in fermented milks has recently been reviewed (8). It has been found that the organism may be able to grow in some buffered culture media used for the preparation of starters, and that contaminated starter cultures are a potential source of *Listeria* in the finished product. Studies with both cultured buttermilks and yoghurts inoculated with *L. monocytogenes* before fermentation showed that survival was influenced by starter culture type, fermentation temperature and final acidity. In some fermented buttermilks, viable cells could be recovered after twelve and a half weeks of refrigerated storage (9). Survival times in yoghurt have been found to be shorter, and, in general, the lower the pH of the finished product, the shorter the survival time. Survival of *L. monocytogenes* inoculated into yoghurt after fermentation (possibly a more realistic scenario) has also been investigated. Survival for up to 3 weeks was recorded, although the majority of the cells were inactivated in the first 12 days (10). A UK survey of 100 samples of retail and farm-produced yoghurts showed that all the samples were negative for *L. monocytogenes* (11).

6.9.2 Escherichia coli

In general, *E.coli* is rapidly inactivated by lactic fermentation; a study showed that rapid inactivation of *E.coli* occurred in 4 days at 7.2 °C when it was added to yoghurt samples (12). However, the unusual acid tolerance of verotoxigenic *E.coli* O157:H7 is of concern, and in 1991 an outbreak occurred in north-west England, associated with locally produced live yoghurt. The organism could not be isolated from the yoghurt or milk, but epidemiological evidence indicated a link (13). Recent studies have demonstrated that *E.coli* O157:H7 inoculated into commercial yoghurt and other fermented milks, survived for up to 12 days in yoghurt, and for several weeks in sour cream and cultured buttermilk and that the addition of sugar to cultured milk products enhances survival of *E.coli* O157:H7 (14). Studies have also shown that *E.coli* O157:H7 capable of producing colonic acid persist longer in yoghurt (15). Contamination of these products with the organism is therefore a potential health hazard, since the infective dose is thought to be low (16).

6.9.3 Staphylococcus aureus

Staph. aureus is very unlikely to grow in fermented milks; however, a case of staphylococcal food poisoning was reported in 1970. The cause was attributed to the high sugar content of the product, which favoured *Staph. aureus* growth and toxin formation, while inhibiting the starter culture (lactic acid) (12). Survival in inoculated sour cream, cultured buttermilk and yoghurt has also been shown. In sour cream inoculated at a level of 10^5 cells/g, viable cells could be recovered after 7 days, but this was not the case at lower inoculation rates (17). The survival of *Staph. aureus* during fermentation and subsequent storage has also been studied,

with similar results. At high inoculation rates, viable cells survived through fermentation, but died out during chilled storage (18).

6.9.4 *Clostridium botulinum*

In 1989, there was a well-documented outbreak of botulism in the UK associated with hazelnut yoghurt. The contamination was not as a result of a problem with the manufacture of the yoghurt itself, but with underprocessed hazelnut purée, added as a flavouring. The purée had been prepared with artificial sweeteners instead of sugar. As a result, the raised water activity allowed *C. botulinum* spores to germinate and produce toxin (19). Although an unusual case, this incident emphasises the importance of controlling the microbiological quality of those ingredients added after fermentation. Proper application of HACCP principles to new product development processes should minimise the risk of problems like this occurring.

6.9.5 *Yersinia/Aeromonas spp.*

The ability of these organisms to grow at low temperatures suggests that their presence in fermented milks could be a hazard. The growth and survival of both organisms in yoghurt have been investigated. *Aeromonas hydrophila* was found to be completely inhibited after 5 days of refrigerated storage, but *Yersinia enterocolitica* could still be detected at the end of shelf life after 26 days (20). However, as with other pathogens, survival through fermentation and storage is probably dependent on the rate of acid production and the final pH. A later study determined survival times of only 5 days for *Y. enterocolitica* during chilled storage (21).

6.9.6 *Bacillus cereus*

Spore germination and growth of *B. cereus* in fermented milks are prevented by low pH. However, growth of *B. cereus* has been shown in yoghurt milk at 31 °C, although, as the pH dropped, the growth rate declined, and it ceased at pH 5.7. Although it is possible that high levels could be reached when initial acid production is slow, *B. cereus* is not normally considered a hazard in fermented milks (22).

6.9.7 *Toxins*

If the milk used to produce yoghurt and other fermented milks is contaminated with mycotoxins, probably through contaminated animal feed, it is possible that the finished product will also be contaminated. It has been shown that aflatoxins

are stable during the manufacture of yoghurt and subsequent chilled storage for 21 days (23).

Concern has also been expressed regarding mycotoxigenic moulds growing on the surface of yoghurt, following the isolation of the toxigenic species *Penicillium frequentans* as a contaminant in a commercial yoghurt sample (24). However, since mycotoxin production would be expected to coincide with visible growth, and visibly spoiled products are unlikely to be consumed, this does not seem to be a serious hazard.

6.10 Probiotic Products

Since many probiotic cultures used to ferment milk are slow acid producers, it may be that there is an increased opportunity for contaminating pathogens to grow to dangerous levels before the pH drops to inhibitory levels. For this reason, it becomes even more important to implement effective hygiene procedures to ensure that potential pathogens are not able to contaminate ingredients or the processing environment.

Concern has also been expressed over the safety of some probiotic cultures, particularly strains of *Enterococcus faecium*, which may be an opportunistic pathogen, and display multiple antibiotic resistance. Therefore, considerable care must be exercised in the selection of probiotic organisms, to ensure that they do not present any discernible health risk to consumers.

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